January 2015

Implementing Lean Techniques for OYO Sports

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Implementing Lean Techniques for OYO Sports

A Major Qualifying Project submitted to the faculty of

WORCESTER POLYTECHNIC INSTITUTE (WPI)

in partial fulfillment of the requirements for the

Degree of Bachelor of Science

On January 29th, 2015

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Abstract

As OYO Sports grows it is vital for their continued growth to implement Lean Techniques in the company. Based on a series of interviews, observations and time measurements the current process at OYO Sports was analyzed and areas in need were identified. For this project Lean Techniques were implemented in redesigning the Field set assembly lines, creating a new process for the release of New Products and Hot Market Products. Also a new part dispensing system was designed and implemented on the production floor to ease the bagging operation. Future suggestions include: creating a Lean team and hiring a Lean coach to ensure continued improvement, designing assembly lines before the products release date and the continued use of Kaizen events and Value Stream Maps to address problems.

Acknowledgements

First, I would like to thank every employee at OYO Sports for welcoming me into their family for the duration of the project. Your kindness and support did not go unnoticed.

Second, I would like to thank Emily Wing, Martin Hanssmann, PJ Antonic, and Clayton Camire for allowing me to interview them and giving me a behind the scenes look at your departments.

I would also like to thank Federico Larco, Dawn Paulino, Daniel Comire, Jeffrey Drew and Jim Wright for all your help with this project, you have taught me far more than I could ever ask for.

A special thank you goes to the New Product Development group for all your help with this project and everything else, I will never forget you guys.

I would also like to thank professor Savilonis, whose guidance and support made this project the success that it was. Thank you for everything you have done for me.

Lastly, I would like to thank my sponsors Ryan Rasmussen and Shari Fabiani for taking a chance on me and allowing me to do this project at OYO Sports, it has been an absolute pleasure working with you both.

Executive Summary

After Lean Manufacturing was identified as the leading factor to Toyota Corporation's success, companies all around the world have been trying to duplicate Toyota's success by implementing Lean Manufacturing techniques. In today's competitive market mastering these techniques can be key to a company's success.

After debuting in 2011, OYO Sports has quickly filled a space in the competitive and dynamic sports market. Since then, OYO has grown from two to around a hundred and fifty employees. Over the last year OYO Sports has moved most of its production from China to the United States in order to decrease lag time between developing new products and their release to the market. The sports market is fast-paced, since team rankings and trade are unpredictable; OYO needs to be able to make changes to their products in order to release the updated products in time with the sporting events. Despite the significant growth in a short amount of time, OYO has yet to develop operational quality processes to allow smooth transitioning from a small company to a larger company.

The lack of an Operations New Product process results in low-quality products, order delays and employee frustration. The goal of this project was to implement Lean Manufacturing techniques in order to build a process for OYO Sports that allows the smooth release of new and current products.

After interviewing employees from Sales, New Product Development, Operations and Fulfillment sectors, observing and timing the production floor, the scope of the project was narrowed to the Field set assembly lines and the new product process.

Over the course of this project the Field set and feeder lines were redesigned using line balancing techniques. Using data from interviews, observations and time measurements the tasks were group to create a single flow balanced line.

The current system for the bags uses bins to hold the parts, and workers have to reach into the bin, take out pieces one or two at a time and place them on a tray. The worker then empties the tray into a bag, often picking up the pieces one by one, or attempting to slide them down the side of the tray and risking dropping parts. The bag is then sealed and placed aside to be used in one of the sets.

Three main bottlenecks were identified for the bagging lines: the current bin system, the graphics, and the tray. These problems delayed the line and affected the quality of the parts, resulting in multiple customer complaints concerning missing parts. To address these three problems a new part dispensing system was designed, new graphics were made and the trays were modified.

The new dispensing system is made from pieces of PVC pipe that allow the parts to flow in front of the worker, who can slide the needed parts directly onto their trays. The trays were modified by creating a funnel on the bottom corner in order to make it easier to slide the parts into the bag. Using Photoshop and Solid Work renders the graphics were redesigned, enhancing the colors and enlarging the parts to make it easier to place these parts at their designated positions. Using line testing techniques the graphics were designed to make it easier for the workers to use, and less time-consuming.

For both the Field set lines and the feeder lines a total quality check (TQC) procedure was introduced as part of the design. The procedure consists of each worker checking the quality of the work of the person before them, then doing their work and finally verifying their own work. Unfortunately the only way to measure quality is through customer complaints; however, the Operations department at OYO Sports is confident that by included this quality process in the new line designs they will be receiving less complains. After testing the line changes, I found that the quality did improve while the assembly time decreased by approximately 33%.

Prior to the project the process to release new products involved creating and releasing the product without paying close attention to how it will affect the production floor. This caused problems on the production floor and at times demand could not be met as the Operations department attempted to adapt to the changes. In the newly created process, instead of waiting until products are released, a new assembly line is to be designed and tested prior to the release of the new product. This process was implemented for the new Goalie products a few weeks before their release. This proved to be a success, as everyone is on the same page about what needs to be done before the product is released.

Hot Market Products are the products that are released after key events and sport trades. These products typically have a much shorter timeline than the normal products. One way OYO Sports is addressing the smooth release of Hot Market products and new products is by implementing Product Lifecycle Management software which will allow them to keep track of projects from inception to the products retirement. Unfortunately not everyone is aware of this modification, and very few people know how the process will change. For this project the team and I created a Value Stream Map that follows the new process step by step. This new visual design will make it easier to introduce the process to employees and ease the transition from the old process to the new one.

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Introduction

After Lean Manufacturing was introduced in *The Machine That Changed the World* as one of the driving factors of the Toyota Corporation's success, companies all around the world have tried implementing Lean Manufacturing in their own companies. [18]

Over the last few years OYO Sports has filled a space in the competitive and dynamic sports market by creating collectible limited edition (LE) mini-figures and Field sets that appeal to sports fans no matter their age. One of their main goals is to bring the child out of every fan, in which they have been quite successful. Over the last year, OYO Sports has nearly doubled their size and production, going from seventy employees to nearly a hundred and fifty, and went from selling to small businesses to retailers such as Target and Best Buy. Despite this growth in sales and the workforce, production, sales and new product processes have not been modified to meet this growth. Over the last few months this has caused delays, miscommunication between departments, and employee frustration.

One of the main problems OYO Sports is having is meeting customer demand at times having to run a third shift or have other departments help on the production floor. By running a third shift the Operations department incurs extra charges and the other departments pause their own work to help. To address these problems there are currently several projects being conducted at OYO Sports including the redesign of the LE assembly line and creating a new fulfillment processes. From the data received from the interviews and observations it was determined that one key area in need of improvement are the Field set assembly lines, the process for releasing new products and Hot Market products.

For this project individuals from different sectors of the company including Operations, New Product Development, Sales and Fulfillment were interviewed to understand the problems in each of these departments. Observations were made for the work in each department, and time measurements were taken for the assembly lines in the Operations department. Using the data from the interviews, observations and time measurements the Field set assembly lines were redesigned to meet the current demand. A new product release process was also tested, and additionally, I created a Value Stream Map for the new Hot Market Products.

Chapter 1: Background

OYO Sports

OYO Sports is a sports consumer goods company Founded in 2011 by Thomas Skripps in Acton, Massachusetts, focusing on engaging the kid in all sports fans. Since then, OYO Sports has quickly filled a space to supply toys and collectible toys in the competitive and fast changing sports market. The company began with two employees and one product, and within a few years has grown to around 150 employees and 4000 variations of products. Today, OYO Sports has products with four leagues: MLB, NFL, NHL, and NCAA collegiate football program and looks to expand to other leagues as well. [1]

Currently, OYO Sports has two main product lines: the Limited Edition (LE) mini-figures and Field sets. The (LE) mini-figures is a licensed collectible that shares the likeness of a professional sports player. The Field sets are fields with printed team logos and a few generic mini-figures, which increase the playability of the mini-figures. [1]

OYO Sports currently has two main assembly lines, one for the mini-figures and another for the Field sets. There are also multiple feeder lines leading to these two main lines. For the mini-figures, there is a feeder line from the printing station that prints the team name and player name on the minifigure. For the Field sets, there are feeder lines assembling each of the different bags that go into the set, and the printing station feeding bricks with the team logo, and printing logos on mini-figures to be used on the set.

Over the last year, OYO Sports has moved most of its production from China to the United States to decrease lag time between developing new products and their release to the market. Since the sports market is dynamic, with players being traded at any point in the year, and the unpredictability of the team rankings, OYO needs to be able to make changes to players and sets in a short time to release the updated products in time with the sport events. As the company expands, the need for operational quality processes for a smooth operation is becoming crucial. Despite growing in a short period, OYO has yet to develop operational quality processes to allow the smooth transition from a small company to a larger company. [13]

OYO faces multiple challenges within the fast changing sports market. Since the products are based on real life events, the company needs to be able to release products within days. For example, last year when Matt Fraser made his playoff debut for the Bruins and scored the game winner against Montreal they had to rush through the approvals process and were able to sell mini-figures of him three days later.

Over the last year, OYO Sports has gone from 70 employees to nearly 150 to meet customer demand. This swift growth has caused a few problems in the processes within the company. The processes that were working to meet the demand in the beginning of the year, with only 70 employees, no longer worked. Some departments restructured, while others did not, and communication became more difficult between and within departments and within the departments. This growth has caused communication problems, quality problems, and delays on orders.

To address these problems there are currently multiple projects, similar to the LE line redesign and a complete restructuring of the fulfillment division, that hope to increase the efficiency of OYO Sports. Despite all these changes there are still areas for improvement within the company. One of the areas that was overlooked during the inception of this project is to implement Lean Manufacturing techniques.

Chapter 2: Implementing Lean Techniques study

Lean Manufacturing

Lean manufacturing is a production philosophy that aims to eliminate waste in the production floor. Although manufacturing process thinking can be dated as far back as the Arsenal in Venice, the first documented examples are from the time of Benjamin Franklin. Henry Ford was the first person to integrate an entire production process and was responsible for value streaming operation lines. [2] Henry Ford was able to reduce the time to build a car from 728 minutes to 93 minutes and reduce the cost from $950 in 1908 to $290 in 1927. [12]

After World War 2 Taiichi Ohno built on the already existing internal schools of thought and spread their breadth and use into what became the Toyota Production System (TPS), which was named Lean Manufacturing by James Womack, Daniel Jones, and Daniel Roos, in their revolutionary book *The Machine that Changed the World* (1990). This book launched the themes of the TPS and brought the Lean movement into the West. The term Lean, however, was coined by John Krafcik in a 1988 article based on his master's thesis at MIT Sloan School of Management. [11]

Since then, companies all around the world have seen the benefits in implementing Lean Techniques in all areas of their companies. However, very few companies have been successful in implementing Lean Techniques to their fullest capabilities and integrating the philosophy into their companies. [11]

After implementing Lean Techniques companies find themselves slowly regressing back to the way things used to be before Lean. The main reason is that it is no longer enough to implement Lean Techniques, in today's market you must integrate Lean Thinking into your company. Lean Thinking is a methodology which aims to provide new ways for organizations to organize human activities to deliver more benefits and value to individuals and organizations while eliminating waste. [19]

There are many Lean tools that can be implemented in different areas of the company, for this project a few Lean manufacturing tools were studied to find the best tools to help OYO

Sports. [18] It was determined that the main Lean Manufacturing tools that can help OYO Sports are:

1. Kaizen Events
2. Value Stream Mapping
3. Assembly Methods

These three Lean tools were chosen to help OYO Sports achieve more efficient processes and increase the quality of their products. In the next sections the tools are shown in more detail.

Kaizen Events

For companies to thrive in today's difficult economy and become successful, they must continuously improve their products and services. They must not only improve their ability to create high quality products, but also with the lowest cost and speed possible. They need to also develop new capabilities, go above and beyond to attract and maintain the best employees and provide a healthy working environment. With the ever changing market, and technological advancements, companies need to apply continuous improvement tools to keep their customers happy. One tool that can be used is a Kaizen Event. [10]

Kaizen, in Japanese means good thinking, which leads to continuous growth. Kaizen has been applied to multiple industries like: healthcare, psychotherapy, life-coaching, production floors and many others. The main purpose of Kaizen is that it is a tool for continuous improvement within its desired area. [12]

In the early 1960's, Shigeo Shingo introduced the idea of "zero quality control" which eliminates the need for inspection of products. From this idea, "quality circles" were developed by Tetsuichi Asaka and Kaoru Ishikawa. Quality circles were made to solve problems inon the production floor. A cross functional team would be assembled to analyze and find the root cause of a problem, find a solution and implement it. Toyota quickly adapted quality circles and it became a fundamental part in the Toyota Production System, which was later named Lean manufacturing. One of the more popular names for quality circles nowadays is Kaizen event. [12]

Kaizen events have been implemented in nearly every country that manufactures and mastered by anyone from CEO's to engineers to entry-level workers. No prior education is necessary to implement Kaizen. All it requires is an open mind and a willingness to try new things. [12]

Often times for Kaizen events to be successful, the companies' culture must change before the physical implementation to solve the problem. Lean thinking must be instilled into the culture of the organization for Kaizen events to work as continuous improvement tools. [12]

Kaizen events are typically 2-5 day events that are focused improvement activities. During a Kaizen event a sequestered, cross-functional team designs and fully implements improvements to a defined process or work area. [6] Kaizen events usually gather operators, managers and owners of a process in one place to fix the problem. The main purpose of the event is to improve on the existing process. [7]

At the beginning of the event an overview of Lean Manufacturing is presented to the team. This is followed by an introduction to the problem being addressed. The team then comes up with a list of goals that they would like to achieve during the 3 to 5 days. The problem is then analyzed and if value stream maps were made prior to the event they are also looked at to find ways to solve the problem. Once the problem is analyzed the attendees brainstorm a set of solutions. Finally, an action plan is set in place to begin the solution implementation. [10]

Value Stream Maps

In most companies, no one person can describe the series of activities needed to design, produce, and deliver on a customer request. This gap in understanding often leads to confusion between departments and makes it more difficult to address interdepartmental problems. [18]

Value Stream Maps (VSM) offer a holistic view of how work flows within a company and between different departments and provide a means to establish a strategic direction for making improvement. VSM can show bottlenecks in processes, and can be used as a visual tool to train new and current employees for any process changes. [11]

VSM are beneficial in showing organizations the interconnectedness of various departments and processes. By seeing how the rest of the organization operates, departments will be able to make better decisions, work together in more collaborative ways, and avoid sub-optimization. Looking past improving the workflow within an organization, VSM can also be used as a simple means to orient new hires and show them where they fit within an organization. [11]

There are two types of VSM: a current state map, which reflects how the current organization functions, and a future state map which will show what the organization will look like after various improvements. A detailed action plan must also be made to realize the future state. Lastly, the detailed action plan must be implemented to achieve the future state. [14]

The mapping process involves examining the activities that occur within a department from the start of the process to its end. If an interdepartmental process is being mapped then the activities between the departments are also examined. Time measurements can be added into the VSM to show how long each step in the process takes. The VSM process is an effective way of capturing the current situation, identifying the long term Lean vision, and developing a plan to help get to that vision. [14]

Assembly Methods

There are currently two methods of assembly in manufacturing products: the bench assembly and the line assembly. In the bench assembly the work-piece remains stationary, with all required pieces and necessary equipment at the bench. Line assembly is when the work-pieces are moved through a sequence between operators. Bench assembly is beneficial when working with large products that are difficult to move. Line assemblies are used more often when there are smaller products that do not require a large work space. However, one of the draw backs of a line assembly is that the line needs to be able to move at the same pace between the different operators. [3]

Line assembly lines were discovered to be more efficient in the beginning of the 20th century by Henry Ford when he changed his factories layout to accommodate a Line assembly. With the new Line assembly Ford was able to decrease the time to build a car from 12 hours to 2.5 hours. [5]

There are multiple assembly line methods being use, some of the most popular ones are:

- Modular assembly: an assembly line that involves parallel subassembly lines feeding into a final assembly line. This would involve having multiple operators assembling separate parts of the assembly and then joining them together in the final assembly line.
- Cell manufacturing: allows operators, both human and robots, to perform multiple tasks in the same cell. This is used mostly for assemblies that require the use of robots to assemble.
- Team Production: Operators work in teams of 1 to 4 to perform repetitive tasks to create the entire assembly in their teams.
- U Shaped assembly line: Sometimes a straight line is not the most efficient way to organize an assembly line. By having a U shape or a curve, operators on the inside of the curve can easily communicate with one another and see each other’s work. [17]

Each of the four assembly lines can be used on several products, and some methods can be combined with others to create the most efficient line.

Production floor Layout Designs

There are multiple ways to arrange the production floor depending on the needed outcomes. With each of the four methods above you can create multiple designs for your layout. For example a line of 20 operators or five lines with four operators each both require the same amount of operators and space, however, have very different advantages and disadvantages..

Figure 1 Different ways to arrange lines

Figure 1 shows examples of different production lines. For a larger line there is less set up and clean up since the line is being used for the duration of the work day. However, one of its main drawbacks is that it is more difficult to switch from producing one product to another, and does not allow creating a mixture of different products at the same time which multiple small lines allow. Also problems are easier to address and will not stop production completely. [15]

Value Added vs. Non Value Added Operation

The cost of a product is determined by the cost of all resources used in the production of the product such as raw materials, labor, storage, and transportation to name a few. Therefore, each operation should be evaluated for the value it adds to the final product. A value added operation is a step that adds value to a product. One of the main goals of Lean is to decrease non-value added operations which is a form of waste.

Before any changes are made for a production line you should look for any bottlenecks and identify elements that are value added v.s. non-value added in the line.

Line Balancing

Line balancing techniques have been used since Henry Ford started the assembly line in 1913. [5] Line balancing indicated distribution of total workload among each station equally to decrease idle time. Leveling the workload in a cell or a value stream removes the bottlenecks and improves the efficiency of the assembly line. [15]

Creating a perfectly balanced assembly line is nearly impossible due to the dynamic characteristics of this system. Therefore, there will always be losses in an assembly line. However, being aware of these losses and understanding their sources, assembly line losses can be minimized.

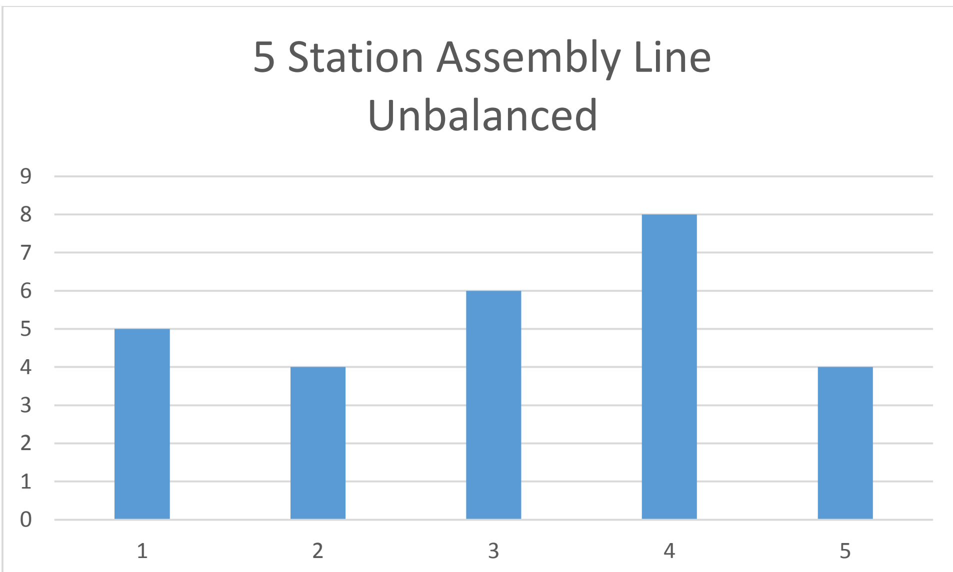

Figure 2 5 Station unbalanced assembly line

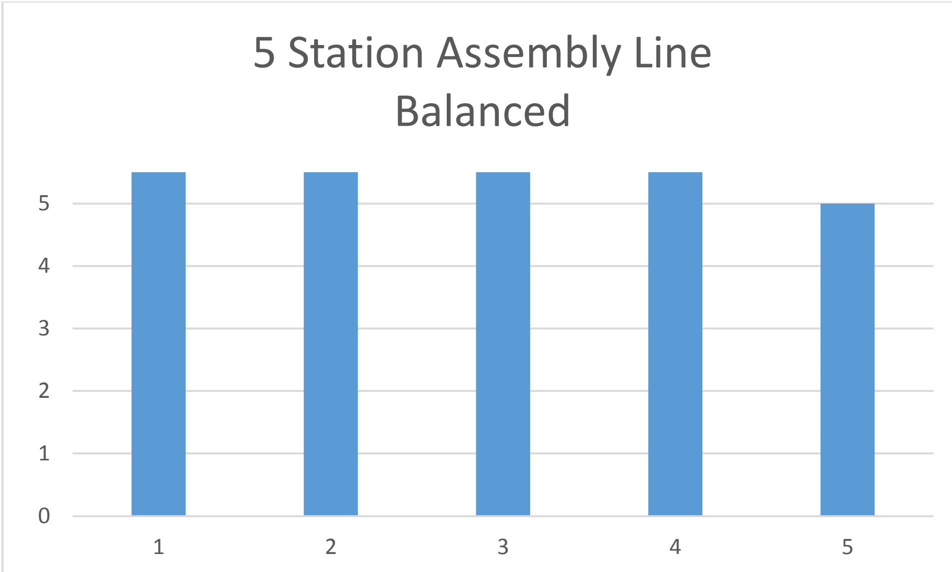

Figure 3 5 Station balanced assembly line

Figure 2 shows an unbalanced assembly line which is made up of five stations and will complete a product every 8 seconds. *Figure 3*, however, shows the same line after the work has been distributed evenly and now a product is complete every 5.5 seconds.

Standardization

When using Line Balancing it is important to standardize the operations to have a base line of how the job should be completed. This enables workers to flow from one line to the next without the need of additional training, and allows management of the process. By managing the process you can quickly fix any problems, and variation from the expected process can be determined more effectively. This is important since one piece flow demands that you are able to resolve issues quickly, otherwise you will not be able to meet the demand. Standardization of the operation also ensures that the process can be repeated by any worker. All this creates a platform from which continuous improvement can be made. [15]

Takt Time

Takt Time is the time it takes to make a single product in order to meet demand. Mathematically it is the total available time for production divided by the total demand. [16]

$$Takt\ Time = \frac{Total\ Time\ of\ work}{Total\ Demand}$$

Actual Work Time

After calculating Takt Time, you must time the process to find the actual time it takes to complete one product and compare the two. The difference will be the amount of losses that need to be minimized to meet demand.

Calculate Manpower

Calculating manpower refers to calculating the number of operators needed for each line to meet Takt Time. Mathematically the total operators needed is the amount it takes to assembly the entire product divided by the Takt Time as shown before.

$$Manpower = \frac{Total\ Work\ Content}{Takt\ Time}$$

Priority of Events

When distributing the work, precedence is one of the most vital piece of data needed. Precedence indicates the order and the priority of tasks between operations in the same line. For example, for a product that requires a box being assembled, a bag and instruction placed inside and finally closed you cannot have the first operator closing the box that does not exist yet. In that case the first assembler must assemble the box, and the last must close the box, the steps in the middle are free to change though unless we want a particular order for the instructions and bag. Using this information we can distribute the work.

Re-allocating work

After removing the non-value added elements, and eliminating the waste in the process the next step is to distribute work to balance the line. Finally you redo the calculations until you meet your Takt Time. *Figure 4* shows the steps to balance to Takt Time.

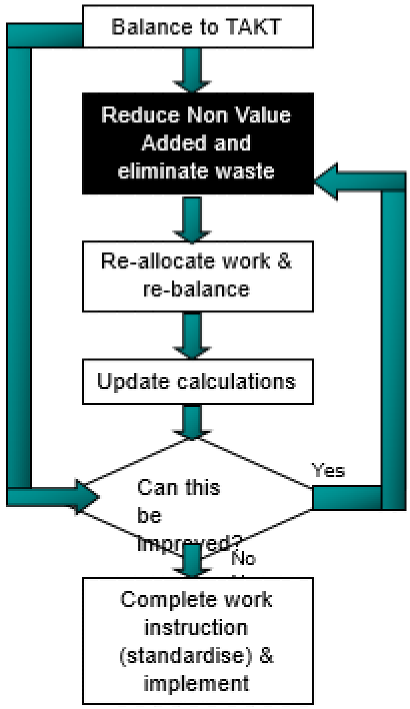

Figure 4 Balance to Takt steps[8]

Total Quality

A Total Quality Check is a quality procedure that requires every operator to verify the work before them, do their work and then check their own work after in assembly lines. If any mistakes are made then the operator that found the mistake informs the rest of the line there is a problem and to pay more attention to each of their work. By verifying each other's work small and big mistakes can be caught either by each operator or the operator after them. This will ensure that every part of the process will be verified before the boxes are sealed and shipped off to the customer. This process takes more time; however, since it decreases rework time it decreases the time.

Chapter 3: Implementation analysis and Results

Methodology

The procedures for this research project were chosen to meet the main project objectives. In order to understand the processes in the different departments at OYO Sports, I chose to interview key individuals from Operations, New Product Development, Sales and Fulfillment. Aside from the interviews, the work from Operations, New Product Development and fulfillment was analyzed to help find the bottlenecks within these departments. Finally, time measurements were taken for the Operation's assembly lines and the lines were balanced.

Interviews

The general methodology used for interviews consisted of three phases: identify possible interviewees, develop interview questions, and conduct interviews. Overall eight employees were interviewed from the four departments. By interviewing key individuals from OYO Sports I was able to not only take a look at their current processes but find the areas that are in need of improvement

Developing Interview Questions

Interview questions were developed based on the background research. The focus of the questions was to find the value added steps and the non-value added steps in the current processes.

Notes were taken during every interview with the interviewees' permission. During the interview, I also asked if the interviewee would be willing to show me some of their work processes or if they could give me a tour of their department. Lastly, I also asked if there was anyone else from within their department or outside it that I should talk to for this project.

Work Inspection

Inspection of the current work in New Product Development, Operations and Fulfillment was critical to the success of the project to observe if everyone follows the departments' processes or if they are constantly changing. A visual inspection was conducted for all three departments for at least a few hours. The visual inspection consisted of observing the work from start to finish, how the employees communicated within the department and with other departments, and how they solved issues that arose during those hours.

By observing the work first hand I was able to see if the processes in place are actually used and where the bottle necks are.

Time Measurements

Time measurements were also taken for both the Operations assembly lines and their feeder lines. Prior to the measurements, each station's work was visually inspected and noted. The measurements were taken using a hand timer from the start of the stations work to the very end. The times for set up and breakdown were not taken into consideration for these timings. At times, the workers would be interrupted. These interruptions were included since they are included in the actual work time. Five measurements were taken, when possible, and the mean and standard deviation were calculated for each station.

By measuring the time it takes to complete each task in the assembly lines, I was able to not only analyze how fast work gets done but also the bottlenecks that are slowing down the line.

Results

According to the individuals interviewed there is some variation in the process for assembling the Field set lines. This was seen during the production flood observations, with the process changing multiple times for a single Field set. According to the employees in Operations one of the biggest problems is employee stability and the lack of work standardization for the Field set lines. Over the last few months it has become increasingly difficult to meet demand, with Operations having to run a 3rd shift or Saturday shifts. Other times, employees from other departments are asked to help in the production floor, disturbing the other areas of the company.

Assembly Method

From the interviews and observations it was determined that the best assembly method would be the line assembly, since all the product are small and they have a small production floor. An assembly line is also more efficient for them. For the assembly line method currently they use the team production method which allows them to create an entire product in a single line. This was the most effective method for OYO Sports again because of the relative small size of the products. Another method that OYO Sports can benefit from us the U shaped unit alongside the team production method. This will allow operators to easily communicate with one another. This will be especially helpful once the TQC is implemented.

Meeting Customer Demand

The main purpose for line balancing the assembly lines is to meet customer demand. For the main goal of meeting customer demand, we needed to decrease the time it takes to assemble each of the Field sets and the feeder lines or to increase the number of lines for each product. Since increasing the number of lines requires more employees which increases the cost needed to assemble the products we decided to redesign the assembly lines, making them more efficient to meet customer demand.

Customer demand was calculated using data from the Sales department forecast for the next six months. After the demand was calculated the Takt time and manpower were calculated.

Field set Name	Customer Demand/day
Outfield	30
Infield	100
Endzone	1200
MLB Game time	200
NFL Game time	300
Zamboni	700
Starter	125
Total Demand	2655

Table 1Total demand by Field set

To meet the demand of 2655 Field sets per day the Takt time is 19s.

$$Takt\ Time = \frac{Total\ Time\ of\ work}{Total\ Demand} = \frac{7hr\ x\ 60\ \frac{min}{hr}\ x\ 2\ shifts\ x\ 60\frac{s}{min}}{2655\ Field\ Sets} = \frac{19s}{Field\ Set}$$

$$Manpower = \frac{Actual\ Time}{Takt\ Time} = \frac{60s}{19} = 3.1$$

On average each assembly line will be formed with three operators.

Initial Time Measurements

After the initial observations time measurements were taken during the first and second shift. The production manager suggested timing the Endzone Field set line since it was being made during both shifts. The shift supervisor noted that depending on the number employees in the production floor the lines change, sometimes operating with 3 or 4 or even 5 workers depending on the demand.

During the first shift the Endzone line had three stations. Each operator tasks were:

1) Operator 1: Assemble the box, place hologram on box and the insert that is placed in the box.
2) Operator 2: Insert three bags and the instructions into the box.
3) Operator 3: Close the box, wafer seal the box, weigh the box to ensure quality and lastly place the box on a rack on the side.

The times for each station are listed in Table 2 along with the average time for each station and standard deviation.

Endzone Set	Station 1	Station 2	Station 3
Time 1 (s)	10.3	21.8	19.6
Time 2 (s)	11.2	16.9	20.7
Time 3 (s)	13.1	22.0	18.8
Time 4 (s)	16.4	16.2	19.9
Time 5 (s)	15.0	19.3	19.5
Avg Time (s)	13.2	19.2	19.7
Std Deviation	2.5	2.7	0.7

Table 2 Endzone Field set times shift 1

The average times for station 2 and 3 were 0.5 second apart, however station 3 has a standard deviation of 0.7 and station 2 has a standard deviation of 2.7. When rebalancing the lines a result of 0.5-0.75 is desirable. Station 1 also does not meet the requirement for the standard deviation.

These time measurements were taken and compared with the Takt time.

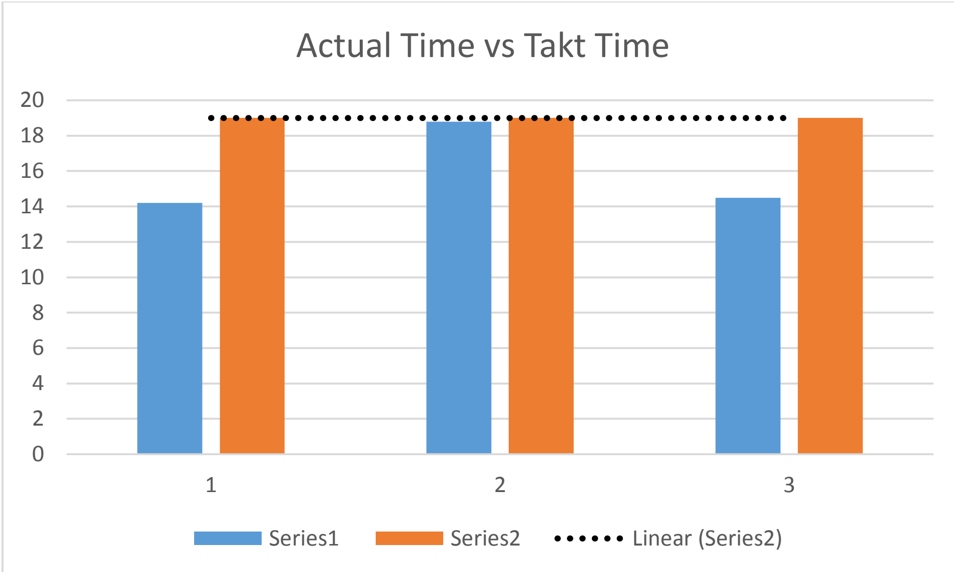

Figure 5 Shift one actual time vs Takt Time

Station 2 and Station 3 are slightly above the Takt time, however station 1 is nearly 6 seconds below Takt time.

During the second shift the operators changed the process three times. The tasks are presented in Table 3.

	Task 1	Task 2	Task 3
Station 1	Place Hologram	Assemble box and insert	Assemble box and insert and one bag
Station 2	Assemble box and insert and insert the bags and instructions	Insert bags and instructions	Insert remaining bags, instructions and weigh box
Station 3	Close the box and wafer seal it	Seal box, weigh box and place aside	Wafer seal box and place aside

Table 3 2nd Shift assembly process

From Table 3 the same three operators changed the process 3 times during the duration of the fifteen minutes. Realizing that station two was taking longer than the rest, Station one started placing one of the bags in the box, and station 2 placed the remaining bags in the box and closed the box, while the third station closed the box. The times for this process are listed in Table 4.

The last change in the process made station 2 quicker by a few seconds as can be seen from Table 4. However, since stations 1 and 2 were quicker than station 3, toward the shift end Station 3 had a pile of boxes that needed to be sealed after stations 1 and 2 completed all their work.

Time measurements were taken for the 2nd and 3rd processes as shown in Table 4.

Endzone Set	Station 1 Process 2	Station 2 Process 2	Station 3 Process 2	Station 1 Process 3	Station 2 Process 3	Station 3 Process 3
Time 1 (s)	10.9	13.8	11.6	14.3	15.1	16.4
Time 2 (s)	15.7	24.1	12.9	14.8	16.9	24.2
Time 3 (s)	12.2	13.1	13.2	14.3	14.2	20.2
Time 4 (s)	10.3	22.0	17.2	16.4	12.9	22.2
Time 5 (s)	21.6	20.9	17.5	12.8	20.2	20.2
Avg Time (s)	14.2	18.8	14.5	14.5	15.9	20.7
Std Deviation	4.7	5.0	2.7	1.3	2.8	2.9

Table 4 Endzone Field set times shift 2 Process

There are two noticeable differences between the data from the first shift and the second:

1) The standard deviations for the second shift were higher than those from shift one.
2) The total time required to complete the assembly was 50 second for the first shift, 47 for process 2 in the 2nd shift and 51 seconds for the 3rd process in the 2nd shift.

   This data shows that the lack of standardization is causing more harm even though at times, as can be seen from process 2 shift 2, more products are made and more operators are meeting Takt time. This also shows that there is room for improvement if the lines are balanced and standardized.

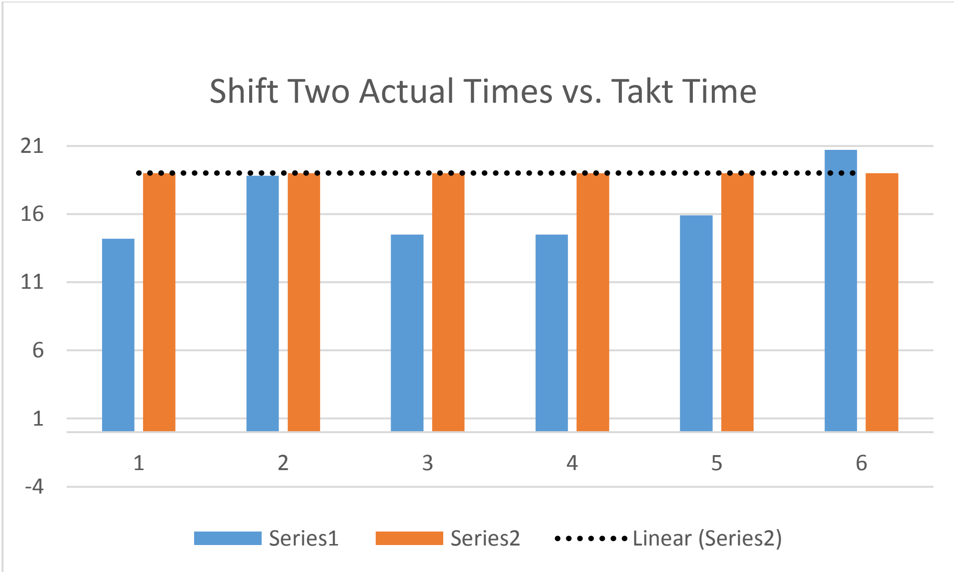

Figure 6 Shift two actual times vs. Takt Time

The difference between the two shifts can possibly be attributed to the change in the process between measurements and more importantly the fact that there is no shift supervisor for shift #2, while the 1st shift has a supervisor that ensures minimum variation in the process.

Individual task times

To determine how long each task takes first the operators on the production floor were timed and each of their tasks were broken down to find the individual task times. These same tasks were tested by other OYO employees to ensure their accuracy. Since Field set operators receive little training we needed times from employees that are not experienced with the assembly line.

Station	***Task***	**Time (Sec)**
1	Hologram Case	6
	Erect Case	14
Total Time		20
2	Box Insert	6
	Team bag	1
	Bag #8	1
	SS Insert	1
	Team Tile Bag	1
	Instruction	1
	Weigh Box	1
Total Time		12
3	Close Box	5
	Wafer Seals	16
	Move to Rack	2
Total Time		23
	Total Time for entire assembly	55

Table 5 Individual task times

The table above shows the individual tasks for the three operators and their times.

Value Added Tasks

The individual task times listed in Table 5 show the time it takes to complete each individual task. From this data three bottlenecks were identified: Placing a hologram on the case, and wafer sealing the case. The hologram and wafer seals are both hard to remove from their rolls and take significantly longer to accomplish than the other tasks which made it a non-value added task. The best proposed solution for this problem was to purchase a hologram and wafer seal dispenser to decrease the time it takes to remove the hologram and wafer seal. With the new dispenser the time to place the hologram decreased to 2seconds and to seal the box with wafer seals was lowered to 5 seconds.

Line Balancing the Field set Assembly Line

From the observations the tasks were analyzed to identify precedence and priority of the individual tasks. .

Task	Operator
Erect Box	1
Erect Box Insert	1 or 2
Hologram	1 or 3
Wafer Seal	3
Place Aside	3

Table 6 Precedence

Table 6 shows the tasks that have priority over others. Using the list of priority tasks the tasks were redistributed. Different combinations of the tasks for each operator were tested and keeping the tasks from every Field set in mind we standardized the work. Instead of giving each operator random tasks we tried to have the same operator do the same job for every Field set. For example, instead of having operator 1 place the hologram on the box for some Field sets and not others we made sure that operator one or three always placed the hologram on the box.

The process was repeated for every Field set line. For every line we completed the tasks as they are currently done on the production floor, identified the bottlenecks and finally redesigned the line. The new lines were tested multiple employees with no prior experience and then by Field set operators. The Field set operators tested each of the lines, giving feedback about the new changes. Using that feedback final changes were made in order to ensure the lines are optimized.

After the event the new design was tested on the production floor by the operators themselves. The operators were asked what they thought of the new process and what changes they think should be made. After taking those changes into consideration the line was modified and tested again on the production floor. Table 6 shows the old and final new line design for the

Endzone Field set. Tables for the Starter, InField, OutField, NFL Game time, MLB Game time and Zamboni sets are in Appendixes II.

Station 1	T(sec)
TQC Box	2
Apply Hologram	2
Flip and Assemble Box	10
	14
Station 2	
TQC Box	1
Put insert into box	5
Insert SS Insert	1
Insert Instructions	1
Place bagged items on tray	2
Verify bagged items	2
	12
Station 3	
Place box on scale	1
TQC Bags and Instruction	2
Verify weight	1
TQC hologram	2
Wafer seal box (3 Seals)	5
Put on Rack	2
Total Time	13 39

Table 7Individual tasks after new design

After line balancing the Endzone we were able to decrease the total work time by 30%. Table 8 shows the decrease in time for each of the seven Field set lines.

Field set	Avg Old Time	Avg New Time	Avg Decrease
Endzone	55	39	30%
Starter	56	40	30%
Infield	56	40	30%
Outfield	56	40	30%
NFL Game Time	75	63	16%
MLB Game Time	92	74	20%
Zamboni	44	38	14%

Table 8Efficiency increase for each Field set

The times in Table 8 show the decrease in the average time it takes for each Field set.

Redesigning the Field set Feeder Assembly Lines

Another area that multiple employees mentioned was having difficulties is the Field set bags. During initial observation of the process many of the workers complained about having to use buckets and trays to fill their bags. Each operator would have multiple buckets, one for each building block piece, in front of them and they would place them on a tray. They complained that the graphics did not have part printed clearly on them and it was easier to count the pieces instead, but the shift supervisor did not approve of them counting, even though it is faster. The reason they were asked not to count was because counting in not as reliable as graphics.

From these observations and the interviews with Operations employees a few problems were identified:

1. Even though picking up the pieces from the bins and placing them on the tray is not very reliable there was no ideal alternative since the graphics were difficult to read.

2. There were no quality checks other than using a scale to weight the bags. However, the scale could not tell if a single piece was missing, only when a significant amount of parts were missing. .
3. It is difficult to move the parts from the tray into the bags, and at times the parts would fall during the process and everyone stops what they are doing to pick up the pieces and they have to recount everything in the bag to insure that they picked up everything.

To address these three problems three solutions were identified: create a new part dispensing system, new graphics that help with quality management, and redesign the trays.

New Trays

To address the problems with the current tray system, we decided to change the system completely. At the time, the trays used were simple lunch trays with the graphic taped on them. Options considered were: pieces of plastic to replace the tray, variations of the tray and no tray at all. The requirements for the design were:

1) Be able to transport parts.
2) Hold the parts in place.
3) Easily transfer parts into bags

In the end we decided to use the same tray; however, we cut a funnel in the bottom right corner, and placed a clear plastic above it so the parts do not fall out when dumped into the bag. Also, since we wanted a new part dispensing system that would allow operators to slide the pieces onto the tray, we needed a flat surface on the front of the tray.

Figure 7 New tray prototype

Figure 7shows one of the prototypes we made and tested. We tried different variations to determine how far the side panels need to go to prevent any parts from falling when placed into bags.

New Graphics

To address the bag operators’ complaint about not being able to count the parts I created new graphics that were clear, easy to use, and easy to check for the quality checks. Figure 8 shows a picture of the old graphics, as you can see some of the pieces are drawn in and on some pieces were taped on the paper since the graphic was not accurate. The new graphics show larger pieces, a lighter shade of the color and they are numbered so it is easy to see the parts when they are placed on the graphics which will be on the trays. After testing out multiple ways to place the parts on the graphic. After testing those two techniques it was determined that having three parts in a row was easier and more time efficient.

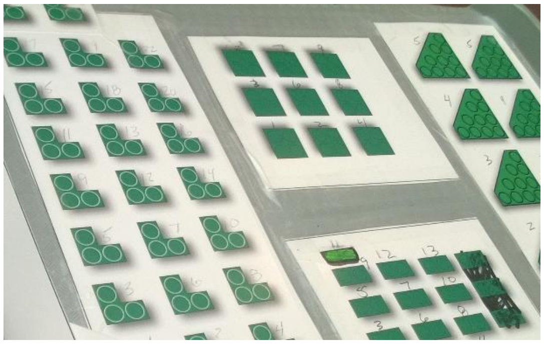

Figure 8 Old graphics

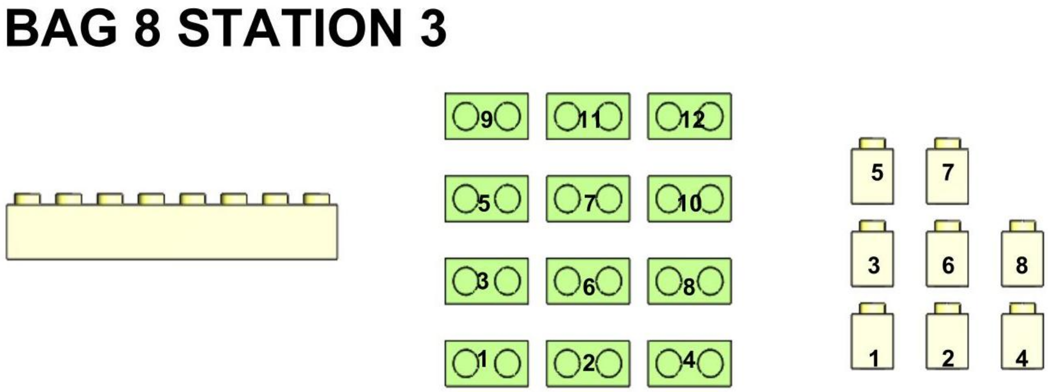

Figure 9 Bag 8 station 3 new tray graphics

Figure 9 shows the new graphic for bag 8 station 3. The remaineder of the graphics can be found in Appendix III. The graphics were made using SolidWorks renders and Adobe Photoshop.

Part Dispensing System

When designing the new system the following steps were used. .

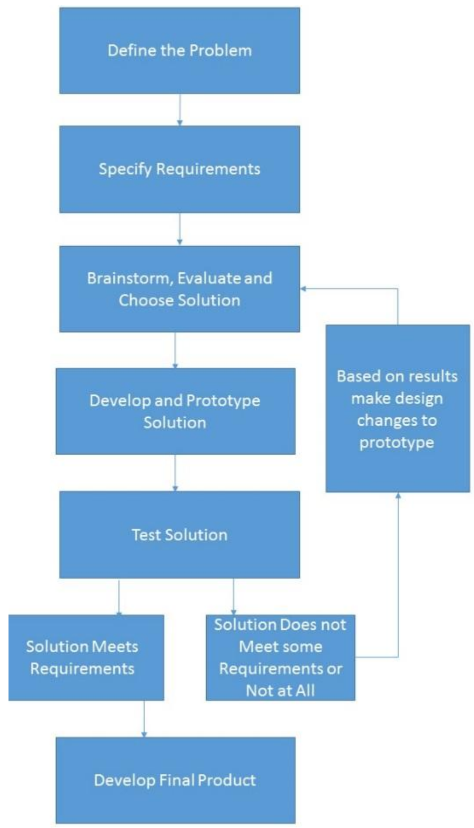

Figure 10 Design methodology for new part dispensing system

Figure 10 shows the engineering decision making process used when designing the new part dispensing system. After defining the problem: placing the parts from the bins takes too long, is not efficient, and caused employee frustration, we set requirements for a new system. There a few requirements for the new part dispensing system:

1. It has to dispense the parts in front of the assemblers to make it easier for them to place the parts on the trays.
2. Has to be easily stored when not used.

3. Easily refillable so the line does not stop every time someone runs out of parts.

We came up with a few different solutions, the two main ones were: using the same bins but creating a hole on one side and a ramp that allowed the assemblers to slide the pieces. The second was using silos and having them dispense the parts onto a ramp. We chose the silo design since it can hold more parts, can be easily stored and is easy to refill.

Figure 11 Silo part dispensing prototype

Figure 11 shows the silo prototype. The Silo design allows parts to be funneled through some tubing that would have an opening in the bottom for the parts to come out of. The workers can slide the part they need directly onto their tray. After testing out the prototype we determined this was the best design to use since it met all of our criteria.

Next, after doing some research for different items I can use I developed a prototype made of PVC piping, PVC 90^0 elbows and wood. I tested out different diameters to determine the best size for the parts and different pipe lengths. The diameter was determined by the size of the building block piece, large pieces were placed in a 3 in pipe to allow the pieces to flow easily, and small pieces were placed in 2 in piping. For the length of the pipe I asked some of the Field set operators to try to fill the pipes with pieces. After the tests, it was determined that the length of the pipe will be 1.5 feet. Each piece of piping was fitted with an elbow to direct the flow of the parts. The piping was mounted 1/4in plywood, using U-bolts. When initially tested too many parts flew out of the pipes, and there was no way to tell how many parts remained in the pipe except if you looked down from the top.

Figure 12 Flow blocking options

To block the flow of parts in the front so the system only releases a few parts at a time I tried two different options *Figure 12*, but neither option worked for all of the pipes.

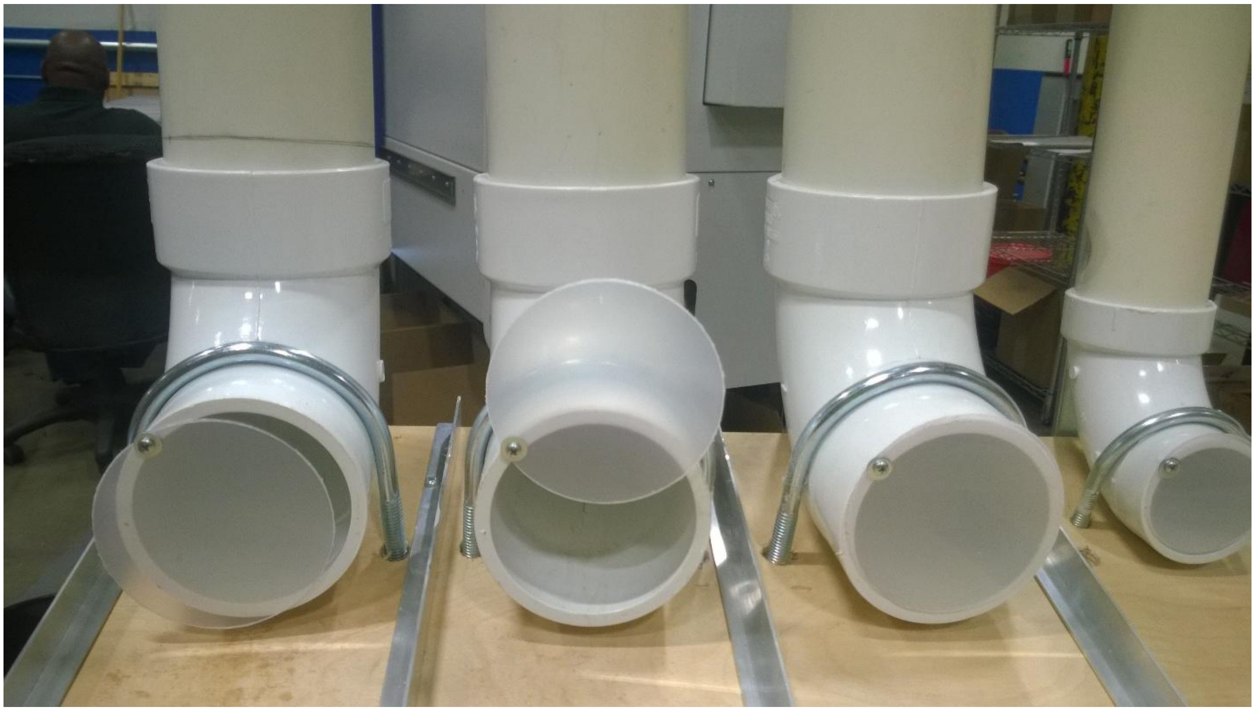

Figure 13 Flow blocking option 3

Ultimately, I came up with a third solution shown in *Figure 13*. This last solution allows us to completely stop the flow of the parts when they tubes are being refilled, while the other ones could not block the flock entirely.

Figure 14 Hole to view remaining pieces

To see how many pieces are left we made a hole in the back of the pipe covered with a wafer seal as shown in *Figure 14*.

After testing the prototype with operators from the Field set lines the design was modified. Next, I made a prototype of lines 8 and 9. With this new design I was able to use a single line for both bags.

The entire line was made up of fifteen small pipes and five large pipes. The order of the pipes had to be standardized to make it easy to switch between lines 8 and 9. After the prototype was complete it was tested with operators to get their feedback. The workers tested the entire system, with the new trays, graphics and the new part dispensing system. The entire design was slightly modified taking the suggestions into considerations and a final version was placed on the assembly line floor as seen in *Figure 15*.

Figure 15 Lines 8 and 9

Rebalancing

After completing the design of the part dispensing system, the new graphics and the new trays the assembly lines were line balanced to ensure they also meet demand.

Before the implementation of the new part dispensing system, new graphics and trays the entire process took too long and there were many complaints from customers concerning missing pieces in the bags.

Time measurements were taken with the new system and compared to the old system as can be seen in Table 9.

Bag #8 Before	Station 1	Station 2	Station 3
	2 x 2, 2 x 2 L	1x2, 1x1 Y, 1x2 Y, 1x8 Y	Skin Pieces, heat seal, weigh
Time 1 (s)	44.35	31	21.89
Time 2 (s)	52.79	19.08	22
Time 3 (s)	45.51	18.08	23.67
Time 4 (s)	35.82	24.64	26
Time 5 (s)	72.94	21.04	20
Avg Time (s)	50.28	22.77	22.71
Total Time (s)			95.76
Std Deviation	14	5.4	2.1

Table 9 Bag #8 times before line balancing

Table 9 shows the time for each station and the standard deviations. The standard deviation for station 1 is 14, which is much higher than our goal of 1.

The new line after being tested with operation workers and optimized is shown in Table 20.

<u>Bag #8</u>			
	Stations Req.	4	
	Time (Sec)		
Station 1	20		***Station 1***
			TQC correct tray
			Place Parts 1
Station 2	24		***Station 2***
			TQC Tray
			Pour Parts 1
			Place Parts 2
Station 3	*21*		***Station 3***
			TQC Tray
			Pour Parts 2
			Place Parts 3
Station 4	22		***Station 4***
			TQC Tray
			Pour Parts 3
			Sticker Bag
Total Time(Sec)	**87**		Weigh Bag
			Seal Bag

Table 10 Bag 8 new design

New time measurements were taken with the new design.

Bag #8 Before	Station 1 After	Station 2 After	Station 3 After	Station 4 After
	TQC Correct Tray, 2x2L, 1x2 Y, 2x2, arms	TQC , 1x2 elbows	TQC, 1x2, 1x8, 1x1	TQC, heat seal, weigh, Place on side
Time 1 (s)	15.8	15.9	15.9	14.8
Time 2 (s)	16.1	15.8	14.9	15.1
Time 3 (s)	16.12	16.0	15.7	14.5
Time 4 (s)	16.1	15.0	15.3	14.7
Time 5 (s)	15.9	15.6	15.5	14.7
Avg Time (s)	16.0	15.6	15.5	14.8
Total Time (s)				61.9
Standard Deviation	0.1	0.1	0.3	0.2

Table 11 Bag 8 times after silo implementation

From Table 11 the new system requires approximately 35 seconds or 35% less time than the previous system. However, the main benefit of the new system is the expected quality improvement which is just as important as decreasing the time it takes to create each bag. Although we have no measurements for the quality after the new line design was implemented. Before the implementation the only data we had was the customer complaints.

The before times are not very accurate since before the silos the process changed from group to group and had a different number of stations from day to day. At times the line would have four or five workers other times there were three stations similar to the measurements in Table 9.

The Operations employees were very impressed with the line. Currently this final design is being used on OYO Sports production floor, along with two other Silo's, one for Bags 1,2 and 3, and another for bags 5,6 and 7.

New Product Process

As OYO Sports expands and increases their product line, it is critical to have a process to create the new product assembly line and have it tested before the product is released. This way Operations can start mass production immediately and there will be less confusion for the workers. Instead of directly releasing the product a meeting will be held weeks in advance and a new assembly line will be made for the new product and any facility restraints will be addressed before the product is publicly released.

We tested out this new process with the new Hockey LE line. Three weeks before the release of the new Hockey LE's we had a three hour meeting to discuss facility concerns and creating a new assembly line for the new product. Prior to the event the current LE assembly line was analyzed, and time measurements were taken.

	Station 1	Station 2	Station 3	Station 4
	Bent Arm, Bent Glove, Checks arm Rotation	Straight Arm, Straight Glove	Legs, Put in Box, Helmet	Puck, Skates, Face Mask
Time 1	7.4	5.7	4.5	4.2
Time 2	10.9	8.0	5.5	5.8
Time 3	10.7	9.4	4.3	4.3
Time 4	9.3	8.1	3.7	3.8
Time 5	7.7	6.7	6.4	8.0
Avg Time	9.2	7.6	4.9	5.2

Table 12 Original LE times

Table 12 shows the times for each station for the LE assembly line.

Since the Hockey LE has similar parts and requires the same amount of workers we decided to use the same area where the current LE line is situated. The current line was modified to meet the needs of the hockey LE line, and then tested with workers from the New Product Development group. The line was tested with five different employees and based on their feedback we finalized the line.

	Station 1 Hockey LE	Station 2 Hockey LE	Station 3 Hockey LE	Station 4 Hockey LE
	Bent Elbow, turn to the right, Straight Elbow	Legs, Place in Box, Helmet and Facemask	Blocker, Glove, Puck, Water bottle	DNA, Sick
Time 1	7.3	6.9	6.0	5.7
Time 2	7.6	6.9	5.7	6.6
Time 3	7.1	6.9	6.2	4.4
Time 4	8.8	6.8	6.2	4.3
Time 5	6.8	5.9	6.1	4.0
Avg Time	7.5	6.7	6.0	5.0

Table 13 Hockey LE line

Table 13 shows the process for the new hockey LE line after being rebalanced using the same techniques used to rebalance the Field set and feeder assembly lines. The new Hockey Line takes slightly less time than the current LE Products since the Hockey LE has one less piece. Since the times between the current LE line and the new line are comparable, it shows that we can use the same space for both lines.

Hot Market Products

The last problem that was addressed for this project was the Hot Market Products process. One thing about OYO Sports is that they have real time manufacturing as the Chief Operation Officer puts it. Because of real time sporting events, and continuous changes to team lineups OYO Sports they have to be able to have products ready and shipped as soon as possible.

Since these products need to be shipped out ASAP employees skip some steps on the process to get the products released sooner. One of the main issues with skipping steps in the process is if things go wrong it is harder to identify where the mistake happened. It also caused delays on some projects since some of the Hot Market products were taking priority away from the normal products and delaying those order. To help create a process that everyone can follow VSM were identified as a valuable tool in introducing this new process and a visual tool to show the new process.

As OYO Sports grows and positions change it is important to have a visual that can show everyone the process especially since they are hoping to start using new software in the near future for better project management for new and current products. The software, Project Lifecycle Management, will allow OYO Sports to manage their products from ideation to when the product is retired. Typically a VSM would include the material, information flow and the times necessary for each step. However, since this process was not finalized and several departments needed to agree on who owns what in the process it was determined that a flow chart to map just the process would be made. OYO Sports planned to hold a Kaizen event to go over this process in more detail and convert this flow chart into a full VSM.

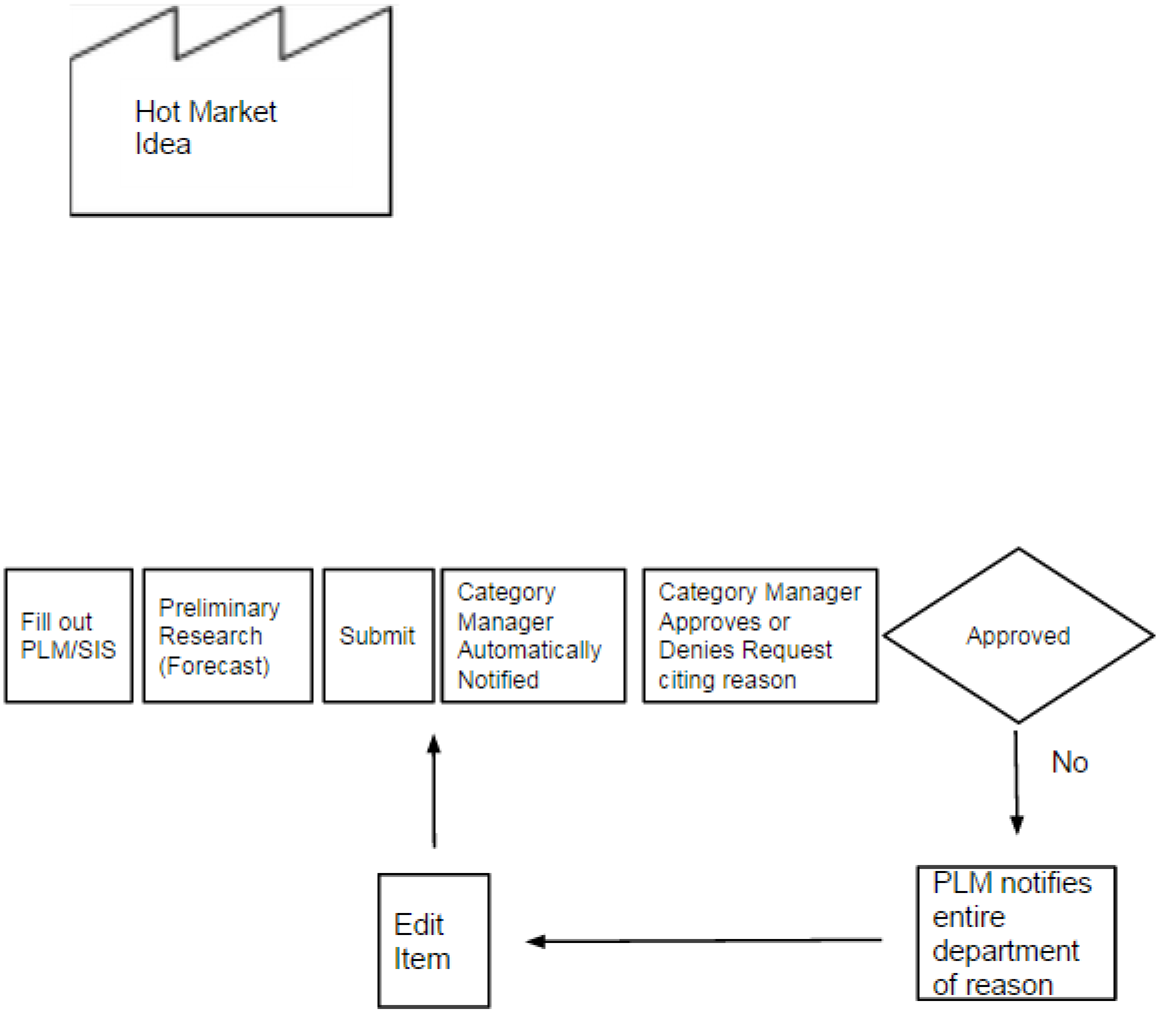

Figure 16 Hot Market flow chart Phase 1

Figure 16 shows the first phase of the VSM for Hot Market products. Once someone has an idea for a product they have to fill out a form in PLM which will include details about the new product and why it should be made. After this form is submitted an employee from the Sales team will do preliminary background research and create a sales forecast for the product. The Sales representative will then submit it again in PLM attaching a copy of the forecast and any relevant documents from the research. A category manager from the New Product Development team will be notified that a new product has been submitted and after reviewing the forecast and the research documents they either approve the product of deny it. If it is approved it moves to the next phase and if it is denied it goes back into PLM and can be edited and resubmitted.

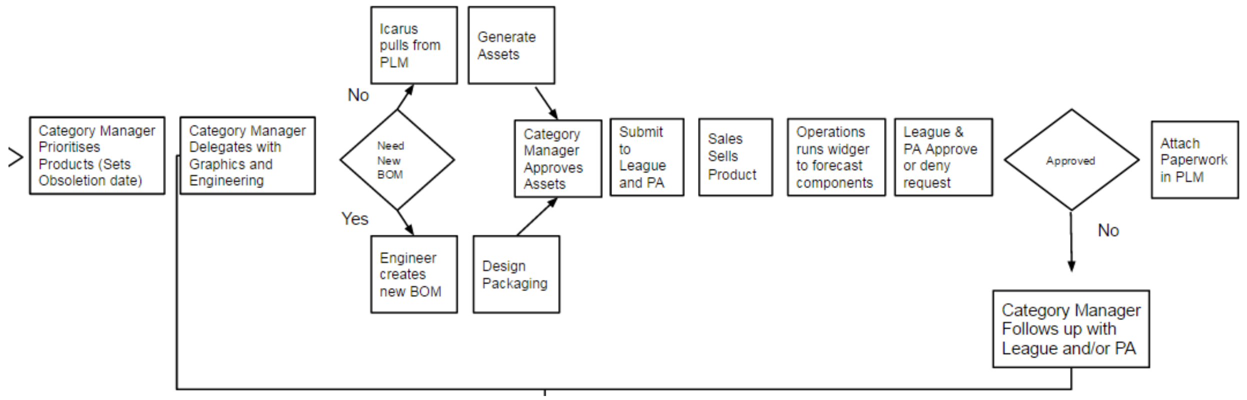

Figure 17Hot Market flow chart Phase 2

Once the product is approved the Category Manager delegates the project to graphics and engineering within New Product Development. If the product is similar to another product at OYO Sports and does not need a new BOM, the graphics department generates images. Once the images are generated, the Category Manager must approve them. If a new BOM is needed, an engineer creates the new BOM listing all the parts of the product and the Graphics team designs the packaging which also needs to be approved. Once the images are approved they are sent to the League and Players Association for approval. At the same time the Sales department will begin selling the new product to their customers and Operations forecasts components and materials for the new product. If the product is approved it moves to phase 3 which is the release of the product. If not the category manager follows up with the League or the Players Association and troubleshoots the product making the necessary changes for it to be approved.

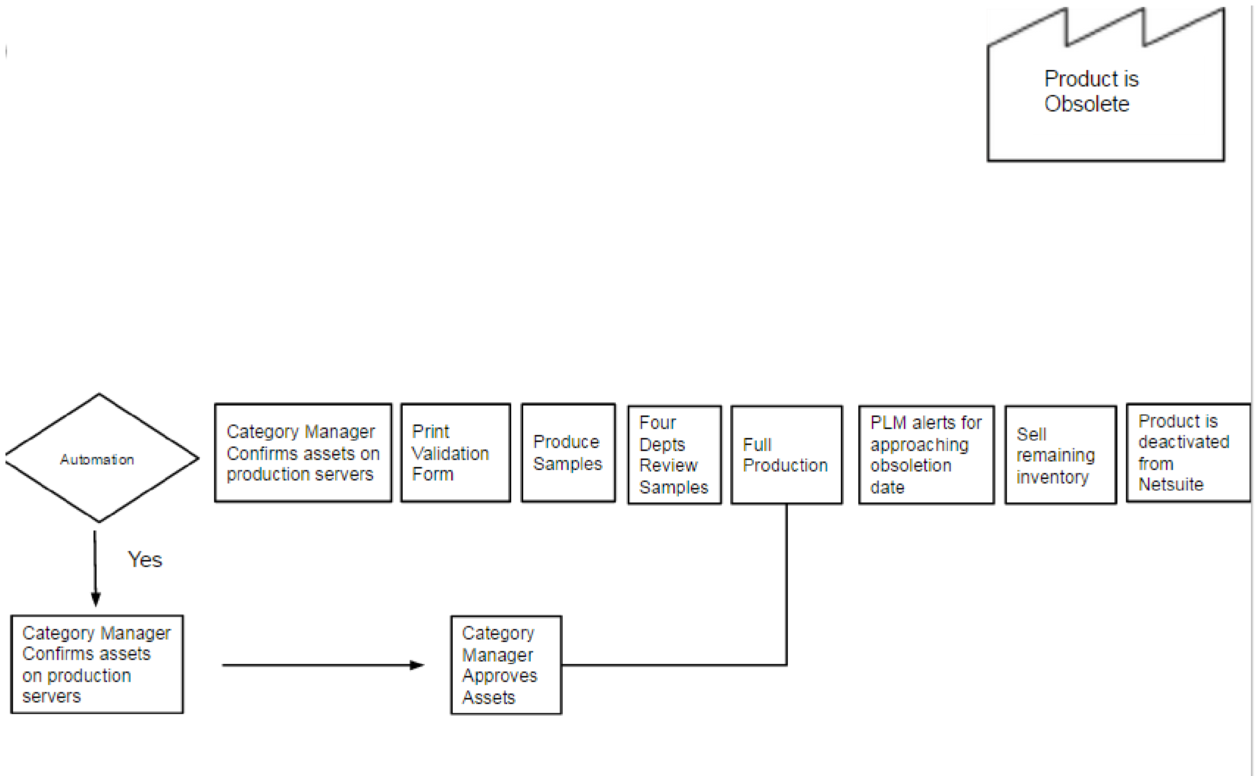

Figure 18 Hot Market flow chart Phase 3

During phase 3 the Category Manager confirms assets on production servers and prints a validation form. The validation form is used to produce samples from Operations and four departments must view the samples and approve it. If the new products can be created using automation software, then the Category Manager confirms the assets are on the production server and full production begins. After the product is released PLM will alert the Category Manager when the retirement date approaches. Lastly, the remaining inventory will be sold and the product will be deactivated.

OYO Sports is at a critical point in its development. By redesigning the Field set lines and their feeder lines they are able to run their current product lines more efficiently and achieve a much higher quality rate. Also, by creating a new process for when products are developed will allow OYO Sports to transition more smoothly into creating new products and mass produce them. Lastly, the Hot Market flow chart will show key individuals how implementing PLM will impact the process, and can be used as a training tool for new employees.

Chapter 4: Recommendations

Recommendations

Transitioning from a small company into a larger company is not an easy task. OYO Sports is doing a fantastic job in increasing sales, employees and creating a work environment that can help sustain growth. However, as OYO Sports grew, some of the areas of the company fell behind slightly causing shipping delays and frustration for some employees. There is room for growth in their current assembly lines, future assembly lines and the way they design future processes to ease this transition.

Currently there are multiple projects in OYO Sports to increase production efficiency and increase the overall quality of the products. These projects include: developing a quality check system, becoming Six Sigma Certified, and moving their production for the parts from China to the USA. However, one main area that needs more focus is the Field set assembly lines. The projects being conducted by the various departments in OYO Sports are a step forward in the right direction. However, when interviewing different departments, it became apparent that not everyone was aware of these projects and at times several departments were duplicating the efforts of other departments working on the same projects and doing the same work that another department had already done.

Recommendation 1: To address this issue my recommendation is to develop a Lean committee. The Lean team should be assembled from a representative from each department and a Lean coach. The Lean coach would be an individual specifically hired to lead Lean projects and train employees on Lean techniques. Since the committee will be formed from members from every department, they will be able to share their projects and progress with each other so everyone is aware of the changes and work being done.

Despite succeeding in developing great products for the sports market, OYO Sports needs to keep up with the ever changing sports market. Over the course of the last year OYO Sports has focused on releasing more and more products,; however, they have neglected updating their assembly lines in time with the increase in sales and new products. This has caused delays and confusion on the production floor.

Recommendation 2: OYO Sports should continue to update their Field set assembly lines as their product line increases. By continuing to update the assembly lines insures that the assembly lines grow at the same pace as the company, and OYO Sports will be able to adjust and fix problems as soon as they arise.

3: Despite having thousands of variations of products, OYO Sports has room for growth when releasing products and starting to mass produce them. Currently, a products assembly line is not created until after the product is released which does not leave a lot of time for making the assembly line more efficient and solving any problems the new line may have. As OYO Sports expands and increases their product line, it is critical to have a process to create the new product assembly line and have it tested before the product is released. This way Operations can start mass production immediately and there will be less confusion for the workers.

Recommendation 3: As part of this project we tested a new process that allows us to create and test new assembly lines before the product is released or needs to be mass produced. I recommend continuing to use this process and make it mandatory for the release of any new product. A team formed from individuals from New Product Development and Operations should be formed before the release of any product and the assembly line should be designed and tested with these key individuals and then tested again with Operations assembly workers. This will allow the smooth release of products and ensures the high quality of the products released.

OYO Sports has grown from a company with two employees to over 150 in just a few years. However, the processes within the company grew at a much slower rate. As demand grew there were no processes that could meet this demand. Once the problem was found every department tried fixing their own processes. Despite fixing their own processes the different departments have yet acknowledge the root of the problem which is that there is no process in place to create new processes before they are needed.

Recommendation 4: As mentioned in recommendation 1, OYO Sports can benefit from creating a Lean team that will guide OYO Sports into developing more efficient products. Whether this team is formed or not, I recommend the use of Kaizen events in all areas of the company to tackle the problems that are slowing down the different departments. The largest problems should be tackled first by multidisciplinary teams to ensure the results are implemented in multiple areas of the company. These teams should try to find the root of the problems and solve them rather than dealing with every problem.

Recommendation 5: To ensure that everyone is on the same page about new processes and how they will be implemented I recommend using a visual tool such as Value Stream Maps, both current and future, to visualize the changes. This way individuals that are not familiar with the old process can easily follow along and see how things are done, and individuals that need to implement the changes in their work will be able to see where the changes are and how they will affect the current process.

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Appendix I Bags New Assembly Lines

Bag #1

	Stations Req. 2	
Station 1	*Time (Sec)*	***Station 1***
	20	TQC correct tray
		Place all parts on tray
		Place sticker on bag
Station 2	*Time (Sec)*	***Station 2***
	20	TQC Verify Tray Contents
		Pour Contents into bag
		Weigh Bag
		Seal Bag
Total Time(Sec)	**40**	

Figure 19 Bag 1 new design

Bag #2

	Stations Req. 2	
Station 1	*Time (Sec)*	***Station 1***
	20	TQC correct tray Place all parts on tray Place sticker on bag
Station 2	*Time (Sec)*	***Station 2***
	20	TQC Verify Tray Contents Pour Contents into bag Weigh Bag Seal Bag
Total Time(Sec)	**40**	

Figure 20 Bag 2 new assembly line

Bag #3

	Stations Req.	1	
Station 1	*Time (Sec)*		***Station 1***
	20		TQC correct tray
			Load Tray
			TQC Verify Tray Contents
			Sticker Bag
			Pour Contents in bag
			Weigh Bag
			Seal Bag
Total Time(Sec)	**20**		

Figure 21 Bag 3 new assembly line

Bag #5

	Stations Req. 2	
	Time (Sec)	***Station 1***
Station 1	20	TQC correct tray
		Place Parts 1
		Place Parts 2
		Move Tray
Station 2	*21*	***Station 2***
		TQC Tray
		Sticker bag
		Pour contents in bag
		Weigh bag
		Seal bag
Total Time(Sec)	**41**	

Figure 22Bag 5 new assembly line

Bag #6

	Stations Req.	2	
	Time (Sec)		***Station 1***
Station 1	20		TQC correct tray Place Parts 1 Place Parts 2 Move Tray
Station 2	*21*		***Station 2*** TQC Tray Sticker bag Pour contents in bag Weigh bag Seal bag
Total Time(Sec)	**41**		

Figure 23 Bag 6 new assembly line

Bag #7

	Stations Req.	2	
	Time (Sec)		***Station 1***
Station 1	25		TQC correct tray
			Place Parts 1
			Place Parts 2
			Move Tray
Station 2	*25*		***Station 2***
			TQC Tray
			Sticker bag
			Pour contents in bag
			Weigh bag
			Seal bag
Total Time(Sec)	**50**		

Figure 24 Bag 7 new assembly line

Bag #8

	Stations Req. 4	
	Time (Sec)	
Station 1	20	***Station 1***
		TQC correct tray
		Place Parts 1
Station 2	24	***Station 2***
		TQC Tray
		Pour Parts 1
		Place Parts 2
Station 3	*21*	***Station 3***
		TQC Tray
		Pour Parts 2
		Place Parts 3
Station 4	22	***Station 4***
		TQC Tray
		Pour Parts 3
		Sticker Bag
Total Time(Sec)	**87**	Weigh Bag
		Seal Bag

Figure 25 Bag 8 new assembly line

	Bag #9		
	Stations Req.	4	
	Time (Sec)		
Station 1	53		***Station 1***
			TQC correct tray
			Place Parts 1
Station 2	53		***Station 2***
			TQC Tray
			Pour Parts 1
			Place Parts 2
Station 3	*53*		***Station 3***
			TQC Tray
			Pour Parts 2
			Place Parts 3
Station 4	50		***Station 4***
			TQC Tray
			Pour Parts 3
			Load Parts 4
Total Time(Sec)	**209**		Touch TQC
			Weigh Bag
			Sticker Bag
			Seal Bag

Figure 26 Bag 9 new assembly line

Appendix II Field set new assembly lines

Endzone

		Stations Req.	3	Set up People	2	
	Qty.					
Station 1		*Time (Sec)*				***Station 1***
Hologram Case	1	6		2		TQC Box
Erect Case	1	14		12		Apply Hologram
			20		**14**	Flip and Assemble Box
						Verify Box Tabs are Locked
Station 2						***Station 2***
Box Insert	1	6		6		TQC tab locks
Team bag	1	1		1		Put insert into box
Bag #8	1	1		1		Insert SS Insert
SS Insert	1	1		1		Insert Instructions
Team Tile Bag	1	1		1		Place bagged items on tray
Instruction	1	1		1		Verify bagged items
Weigh Box	1	1		1		
			12		**12**	
Station 3						***Station 3***
Close Box	1	5		5		Place box on scale
Wafer Seals	3	16		6		TQC bag tray
Move to Rack	1	2		2		TQC instructions/insert
			23		**13**	Fill box
						Verify weight
Total Time		**55**		**39**		Close box
						TQC hologram
*Need to Reduce Wafer Seal Time/Hologram (Feeding Tool)						Wafer seal box (3 Seals)
*Need Work Instructions- Visual aids						Put on Rack

Figure 27 Endzone new assembly line

Infield

		Stations Req.	3	Set up People	2	
	Qty.					
Station 1		*Time (Sec)*				***Station 1***
Hologram Case	1	6		2		TQC Box
Erect Case	1	14		12		Apply Hologram
			20		**14**	Flip and Assemble Box
						Verify Box Tabs are Locked
Station 2						
Box Insert	1	6		6		***Station 2***
Team bag	1	1		1		TQC tab locks
Bag #2	1	1		1		Put insert into box
Bag #6	1	1		1		Insert SS Insert
SS Insert	1	1		1		Insert Instructions
Bag #4	1	1		1		Place bagged items on tray
Instruction	1	1		1		Verify bagged items
Weigh Box	1	1		1		
			13		**13**	
Station 3						
Close Box	1	5		5		***Station 3***
Wafer Seals	3	16		6		Place box on scale
Move to Rack	1	2		2		TQC bag tray
			23		**13**	TQC instructions/insert
						Fill box
Total Time		**56**		**40**		Verify weight
						Close box
						TQC hologram
*Need to Reduce Wafer Seal Time/Hologram (Feeding Tool)						Wafer seal box (3 Seals)
*Need Work Instructions- Visual aids						Put on Rack

Figure 28 Infield new assembly line

MLB Gametime

	Stations Req.	3	Set up People	1	
Station 1	*Time (Sec)*				***Station 1***
	24				TQC Box
					Apply Hologram
					Flip and Assemble box
					Verify Tabs are locked
					Add insert
Station 2	*Time (Sec)*				***Station 2***
	23				TQC Insert Placement
					Insert Instructions
					Insert SS Insert and display bricks insert
					Place bags on tray
					Verify bagged items
Station 3	*Time (Sec)*				***Station 3***
	27				Place box on scale
					TQC bag tray
					TQC instructions/inserts
					Fill box
					Verify weight
					Close box
					TQC hologram
Total Time(Sec)	**74**				Wafer seal box (3 Seals)
					Put on Rack
*Need to Reduce Wafer Seal Time/Hologram (Feeding Tool)					
*Need Work Instructions- Visual aids					

Figure 29 MLB Gametime new assembly line

NFL Gametime

Stations Req. 3 Set up People 1

Station 1	*Time (Sec)*	***Station 1***
	23	TQC Box
		Place hologram
		Flip and assemble box
		Insert 5 16x32's 3 on 1 side 2 on the other
		Verify Box tabs are locked
Station 2	*Time (Sec)*	Verify 16x32 quantity
	21	
		Station 2
		TQC Tab locks
		TQC 16x32 quantity
		Place 2 16x16 on top of 16x32's
		TQC 16x32 and 16x16 level
		Place insert in box
		Put instructions
		Put SS insert and display insert
		Place bagged items on tray
Station 3	*Time (Sec)*	Verify bagged items
	19	
		Station 3
		Place box on Scale
		TQC bagged items and instruction inserts
		Fill box with bags
Total Time (Sec)	**63**	Verify weight
		Close box
		TQC Hologram
*Need to Reduce Wafer Seal Time/Hologram (Feeding Tool)		Wafer seal box (3 Seals)
*Need Work Instructions- Visual aids		Put on rack

Figure 30 NFL Gametime new assembly line

Outfield

		Stations Req.	3	Set up People	1	
	Qty.					
Station 1		*Time (Sec)*				***Station 1***
Hologram Case	1	6		2		TQC Box
Erect Case	1	14		12		Apply Hologram
			20		**14**	Flip and Assemble Box
						Verify Box Tabs are Locked
Station 2						
Box Insert	1	6		6		***Station 2***
Team bag	1	1		1		TQC tab locks
Bag #1	2	1		1		Put insert into box
Bag #3	2	1		1		Insert SS Insert
Bag #5	1	1		1		Insert Instructions
SS Insert	1	1		1		Place bagged items on tray
Instruction	1	1		1		Verify bagged items
Weigh Box	1	1		1		
			13		**13**	
Station 3						
Close Box	1	5		5		***Station 3***
Wafer Seals	3	16		6		Place box on scale
Move to Rack	1	2		2		TQC bag tray
			23		**13**	TQC instructions/insert
						Fill box
Total Time		**56**		**40**		Verify weight
						Close box
						TQC hologram
*Need to Reduce Wafer Seal Time/Hologram (Feeding Tool)						Wafer seal box (3 Seals)
*Need Work Instructions- Visual aids						Put on Rack

Figure 31 Outfield new assembly line

Starter Set

	Qty.	Stations Req.	3	Set up People	1	
Station 1		*Time (Sec)*				*Station 1*
Hologram Case	1	6		2		TQC Box
Erect Case	1	14		12		Apply Hologram
			20		**14**	Flip and Assemble Box
						Verify Box Tabs are Locked
Station 2						
Box Insert	1	6		6		*Station 2*
Team bag	1	1		1		TQC tab locks
Bag #1	1	1		1		Put insert into box
Bag #3	1	1		1		Insert SS Insert
Bag #5	1	1		1		Insert Instructions
SS Insert	1	1		1		Place bagged items on tray
Instruction	1	1		1		Verify bagged items
Weigh Box	1	1		1		
			13		**13**	
Station 3						
Close Box	1	5		5		*Station 3*
Wafer Seals	3	16		6		Place box on scale
Move to Rack	1	2		2		TQC bag tray
			23		**13**	TQC instructions/insert
						Fill box
Total Time		**56**		**40**		Verify weight
						Close box
						TQC hologram
*Need to Reduce Wafer Seal Time/Hologram (Feeding Tool)						Wafer seal box (1 Seal)
*Need Work Instructions- Visual aids						Put on Rack

Figure 32 Starter set new assembly line

Zamboni

	Stations Req.	3	Set up People 1
Station 1	*Time (Sec)*		***Station 1***
		14	TQC Box
			Place hologram
			Flip and assemble box
			Verify Box tabs are locked
Station 2	*Time (Sec)*		***Station 2***
		13	TQC Tab locks
			Fold Instructions and place in box
			Insert SS Insert
			Place bags on tray
			Verify bagged items
			Verify Instructions and Insert
Station 3	*Time (Sec)*		***Station 3***
		11	TQC bag content and instructions/insert
			Place box on scale
			Fill box with bags
			Verify weight
			Close box
Total Time (Sec)	38		TQC Hologram
			Wafer seal box (1 Seal)
			Put on Rack
*Need to Reduce Wafer Seal Time/Hologram (Feeding Tool)			
*Need Work Instructions- Visual aids			

Figure 33 Zamboni new assembly line

Appendix III New tray graphics

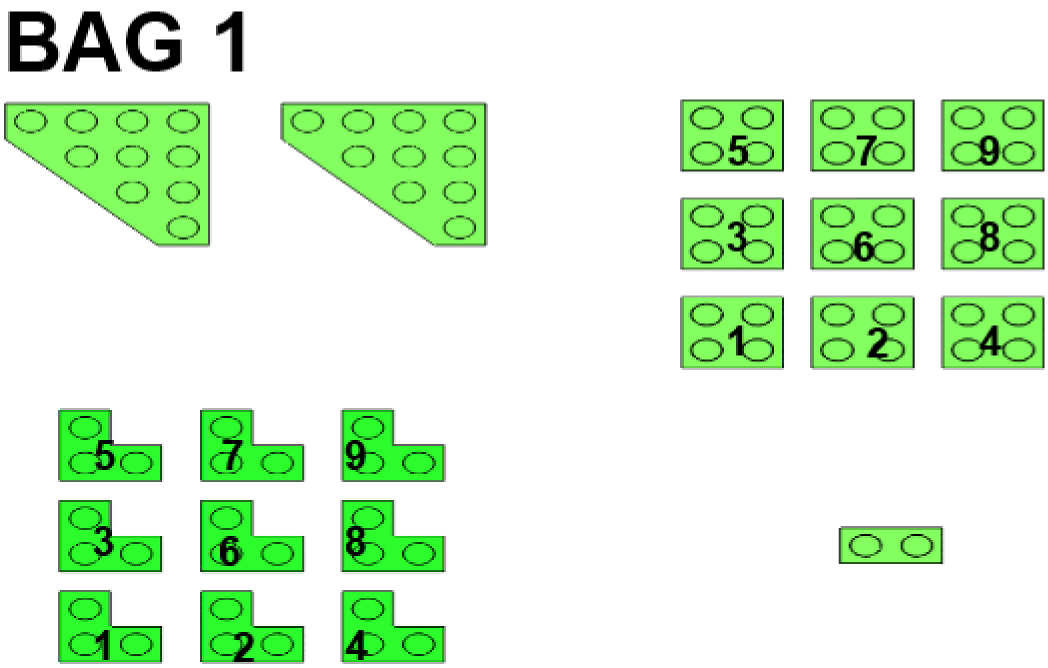

Figure 34 Bag 1 new graphics

Figure 35 Bag 2 station 1

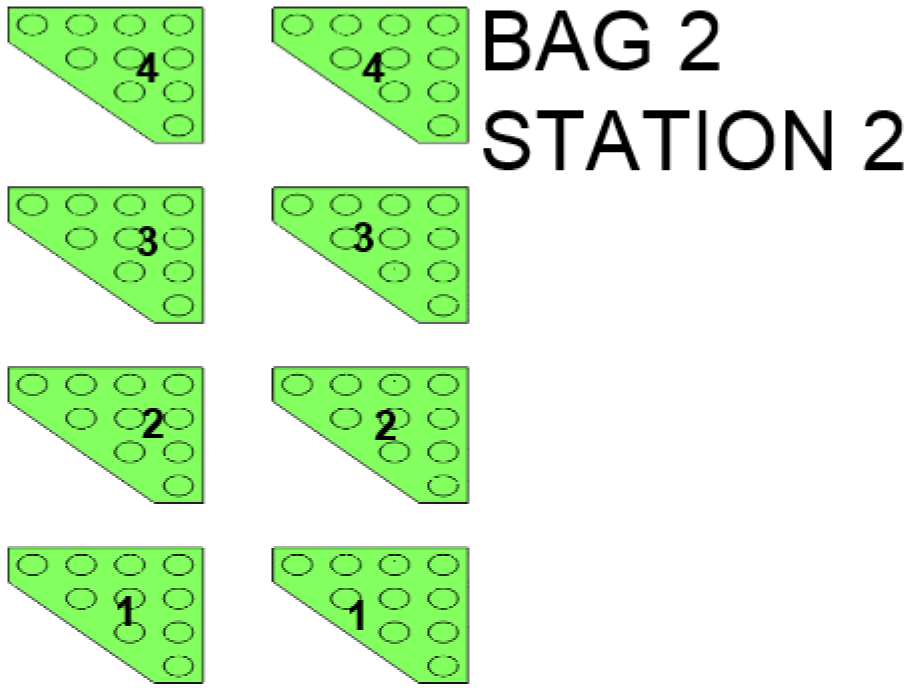

Figure 36 Bag 2 station 2

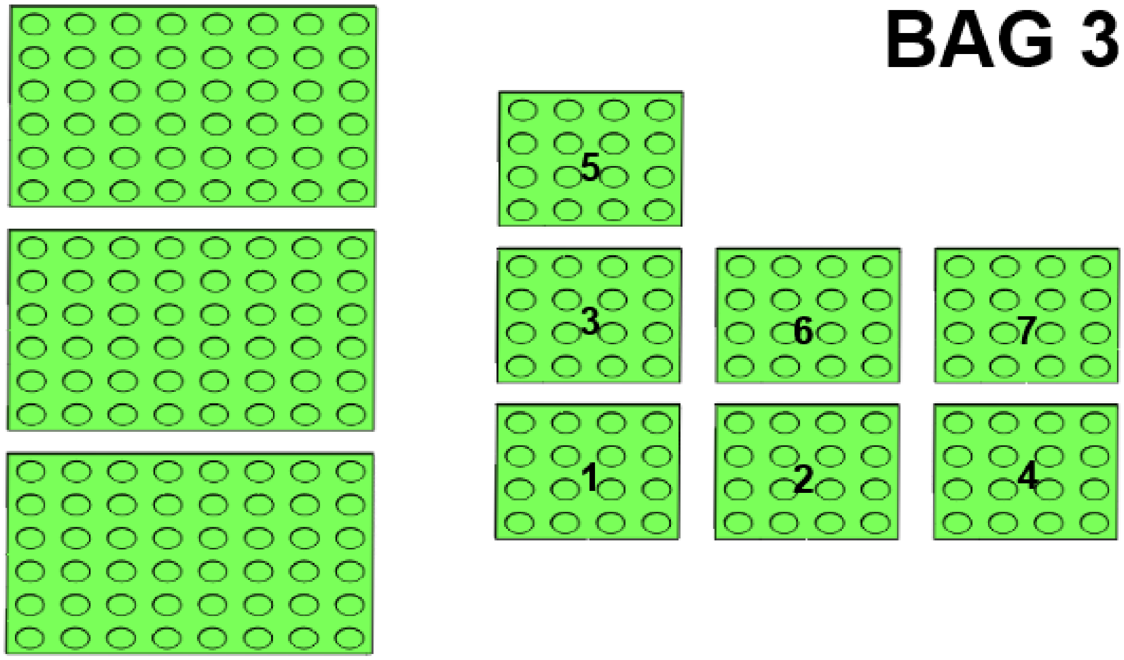

Figure 37 Bag 3 new graphic

Figure 38 Bag 5 new graphic

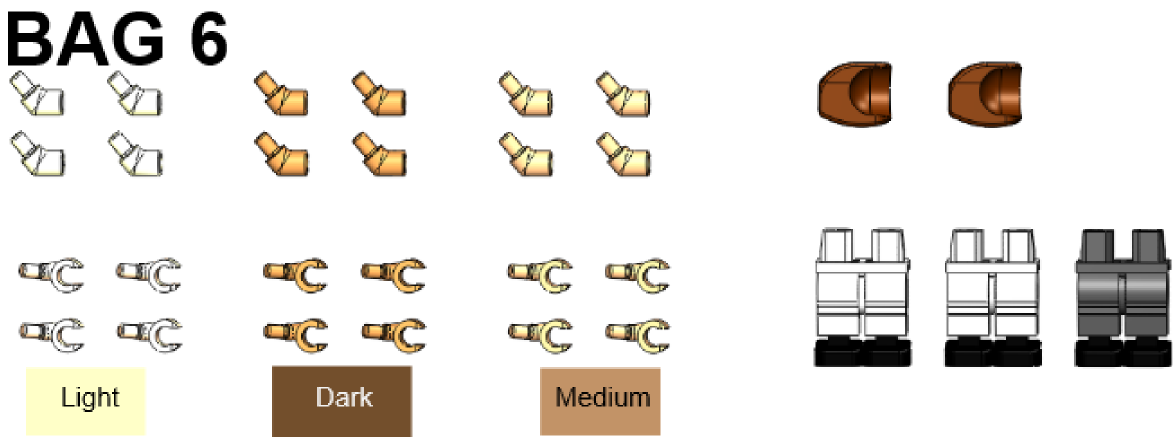

Figure 39 Bag 6 new graphic

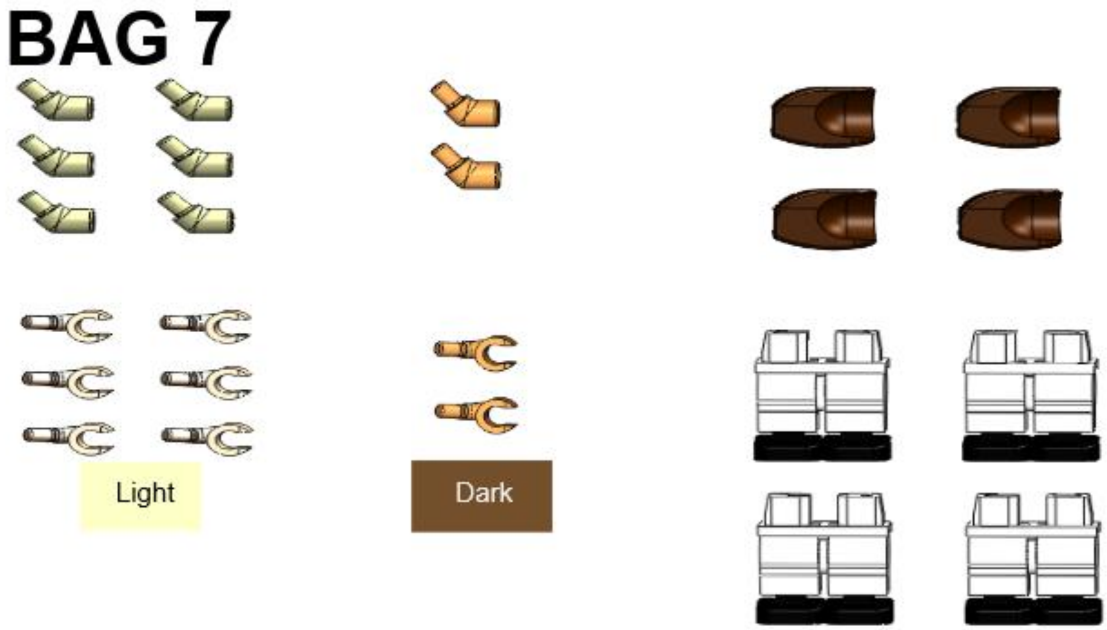

Figure 40 Bag 7 new graphic

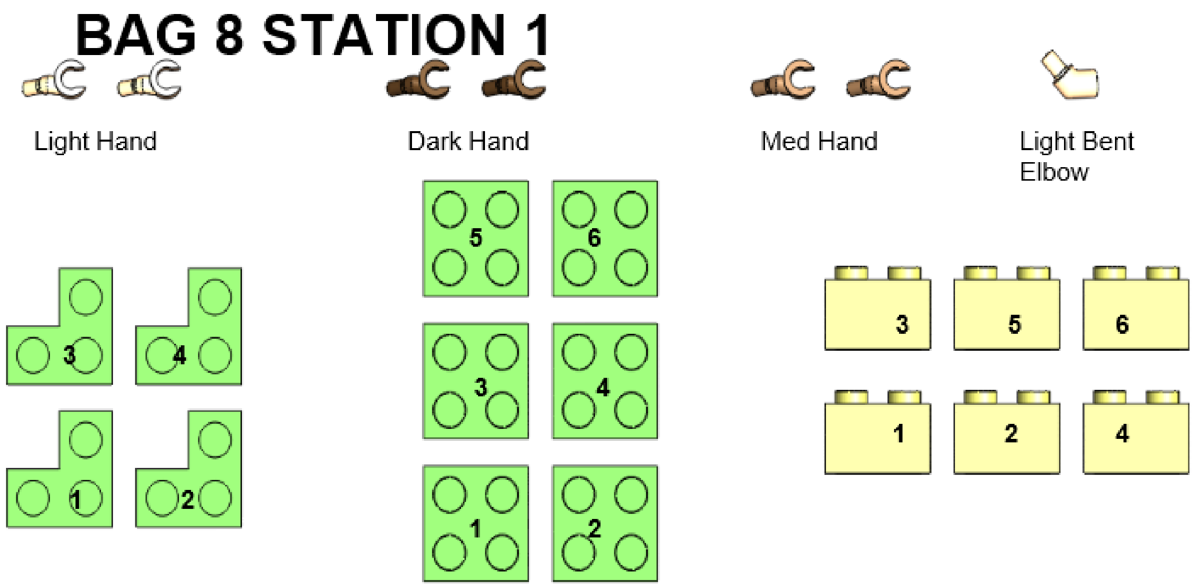

Figure 41 Bag 8 new graphic

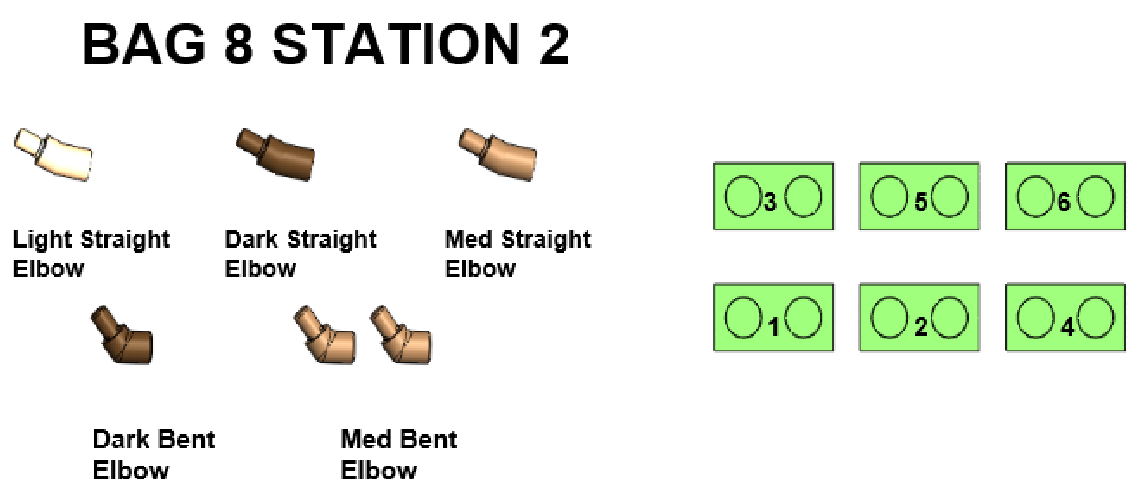

Figure 42 Bag 8 station 2

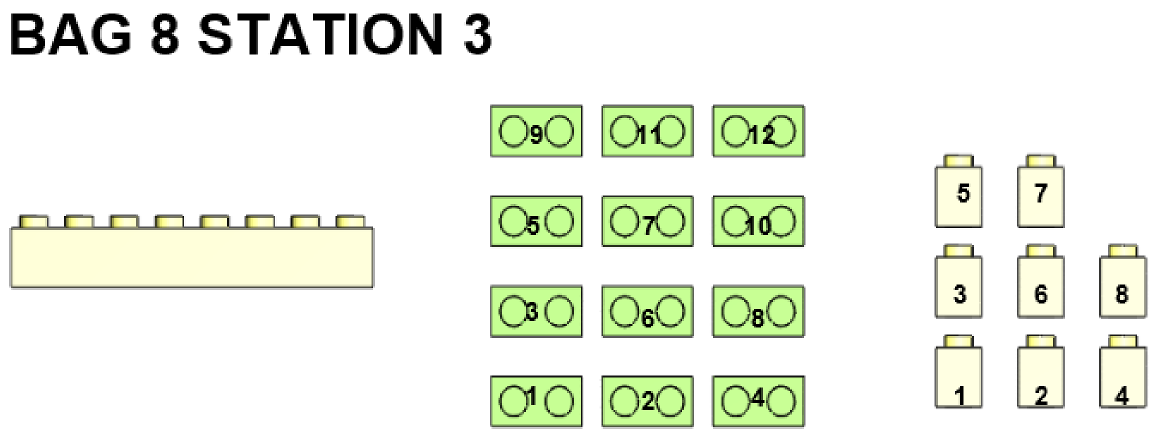

Figure 43 Bag 8 station 3

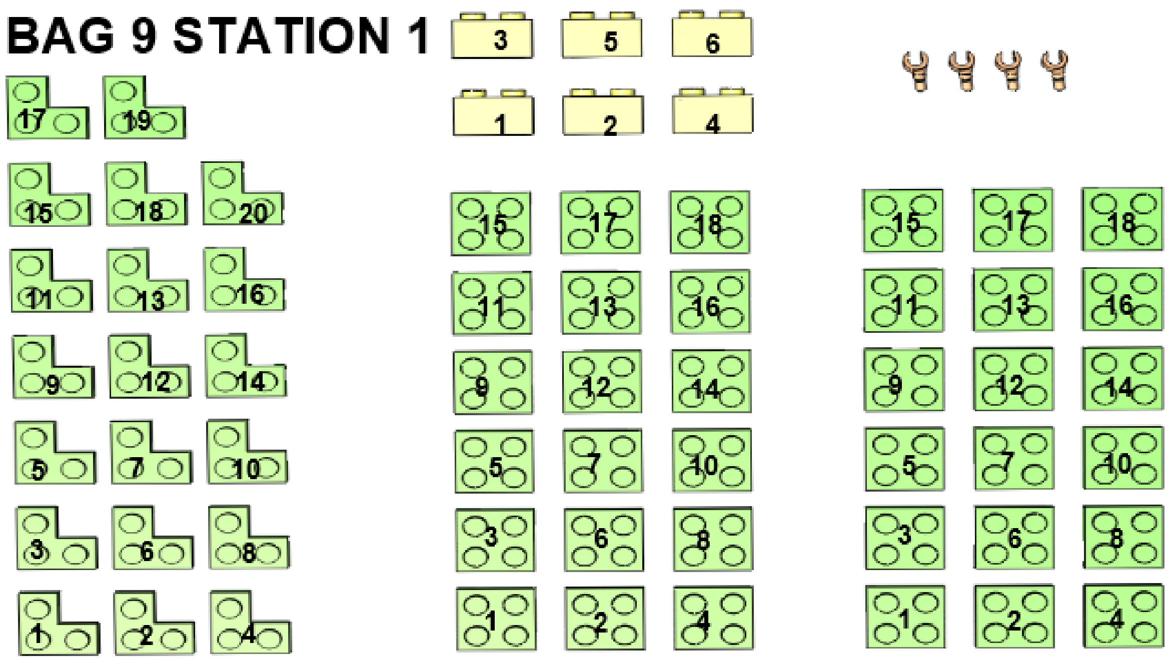

Figure 44 Bag 9 station 1

Figure 45 Bag 9 station 2

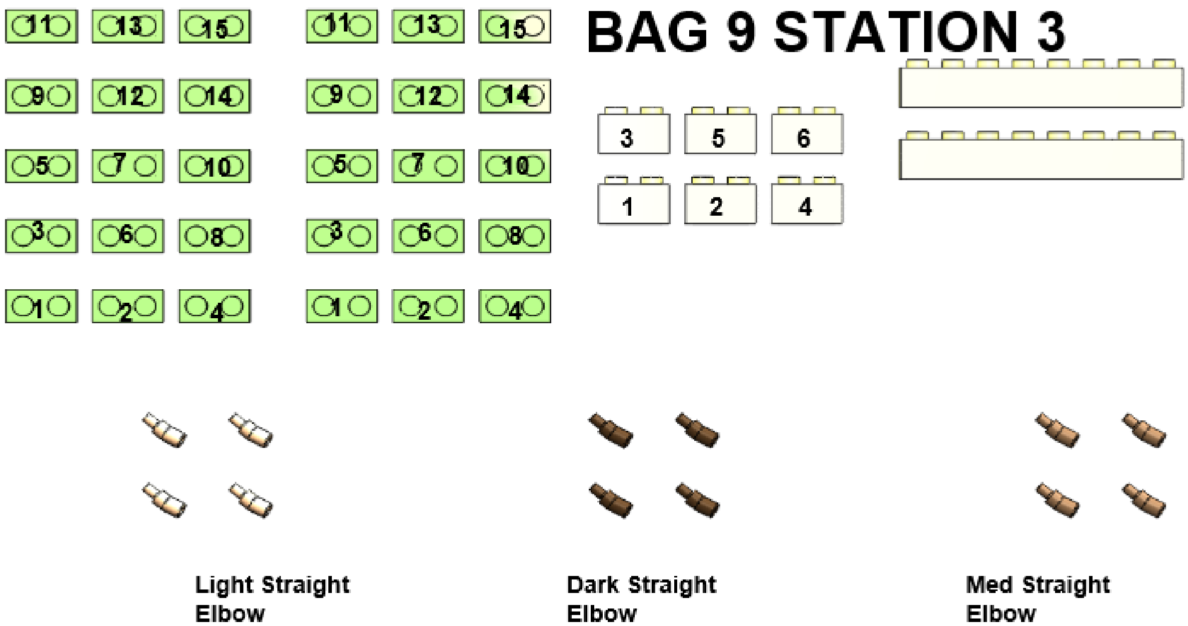

Figure 46 Bag 9 station 3

Figure 47 Bag 9 station 4